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MISCELLANEOUS RECORDS OF INSECTS INHABITING THE SALINE WATERS OF THE CALIFORNIAN DESERT REGIONS

BY W. H. THORPE, PH. D., M. A.

Imperial Institute of Entomology

The insect fauna of brackish waters of the western United States of America is a subject which has attracted the attention of entomologists since the observations made by A. S. Packard in 1869. Since that time much new information has been placed on record, mostly in the form of brief notes scattered throughout a variety of natural history journals. Many of these observations are of little scientific value in that no exact data as to the composition of the water are given. To say that the water is "brackish" or "salt" is so vague as to be practically meaningless. In the case of pelagic forms occurring in large bodies of water, such as Great Salt Lake, this lack of data is of no great significance, since the salinity is generally fairly constant and uniform, but in the smaller lakes which are fed by intermittent streams or springs, and which are liable to become very much more concentrated during the dry summer months, it is important to obtain exact data as to the salinity of the medium at the actual spot where the insects are collected. In such lakes one frequently finds very great variation in density within quite short distances and there may be very marked differences between the surface and the bottom layers. Moreover, pools which appear closely similar may differ enormously in salt content. It follows, therefore, that unless great care is taken the observations may be quite misleading.

The following notes were made, as opportunity offered, during various expeditions into the desert regions of California during 1928 and 1929. The observations are unfortunately very disconnected and incomplete, but as they are accompanied in most cases by exact data as to the environmental conditions the writer feels that they are worth putting on record. Owing to the inaccessibility of many of the localities, details as to the life history and the degree of salinity which the various developmental stages are capable of withstanding are not known and will probably remain unknown for a long time to come. Such information, combined with a knowledge of the salinity variations throughout the year, would, however, be of the greatest interest for the work of Poisson (1924) and others, and has shown that a density which is quite harmless to an adult insect or to a late stage larva may, nevertheless, be sufficient to destroy the eggs or young larvæ, perhaps by interference with the hatching mechanism. Were such details known the reasons for the apparently capricious distribution of many of these halophilus insects would doubtless be more obvious.

It is to be hoped that others will follow up this line of work. A collector with more time at his disposal would not only be able to add to our knowledge in the ways outlined above, but would probably extend considerably the list of species from an area such as Death Valley. Owing to the great variations in the physical and chemical conditions a species may be very abundant in one spot, where conditions are at the optimum, and yet be nonexistent elsewhere, consequently even in a small area a great deal of collecting is needed before one's list is complete.

Death Valley Region.—A brief trip to the Death Valley region of California (Inyo County) was made during February 23-27, 1929. The south end of the valley was first visited. Where the bed of the Amargosa River was crossed no water was seen, but at camp near Old Confidence Mill biting midges were very troublesome, *Culicoides varipennis* Coq., and *Leptoconops kerteszi* var. *americanus* Carter, being taken. Various species of the genus *Culicoides* are known from salt and brackish waters in many parts of the world, and the species above referred to had no doubt bred in the highly saline temporary pools which represent the Amargosa River. *C. varipennis* is already known as a common fresh-water breeder in California and New Mexico, and *L. kerteszi* also breeds in fresh water in north and central California, as well as at Great Salt Lake, Utah.

Some collecting was done at Salt Creek and McLean Springs, on the valley floor, about two miles southwest of

Stovepipe Wells, on the 25th of February. A trickle of water running over the alkali caked mud at Salt Creek yielded the following results:

Coleoptera:
- Dytiscidæ. *Hydroporus panaminti* Fall; *Hydroporus* spp. (larvæ of two species).
- Hydrophilidæ. *Octhebius rectus* Lec.; *Enochrus diffusus* Lec.

Diptera:
- Chironomidæ. *Orthocladius* sp. (larvæ and adults).

Two still pools at McLean Springs, "a" and "b," about eighteen inches deep and three feet in diameter, were also examined. The first contained the unidentifiable remains of a dragon fly larva, and at its margin the salt marsh Carabid, *Tachys vittiger,* was obtained. Pool "b" gave further specimens of *H. panaminti* and some empty caddis cases (Limnophilidæ), and in a very small pool near by *O. rectus* was again taken.

Further south collections were made in shallow pools connected with a slow-flowing stream on the east side of the valley floor, about one and a half miles north of Old Harmony Borax Mill. Here *H. panaminti* was again found, together with two species of *Hydroporous* in the larval stage. Besides *O. rectus* and a larva referable to it, larvæ of *Ephydra* sp. (*hians* ?) were present in considerable numbers.

Hurried collections made in a less concentrated pool at Eagle Borax Well yielded another Hydrophilid, *Tropisternus californicus* Lec., and larvae of a species of *Procladius.*

The salinity of these various waters, in parts per million, is given below:

	Salt Creek	McLean Springs "a"	McLean Springs "b"	Pools Near Old Harmony Mill	Eagle Borax Well
Cl	7,228	2,378	2,840	11,863	412
CO_3	48	0	0	0	0
HCO_3	50	537	500	850	135
SO_4	3,272	1,610	1,710	3,766	597
Ca	112	100	92	84	128
Mg	78	53	30	27	61
Na	6,200	2,300	2,737	9,010	345
Borax	60	20	40	300	10
Total	17,048	6,998	7,949	25,900	1,688
Sp. gr.	1.016	1.006	1.007	1.024	1.001

Owens Lake.—A visit was paid to Owens Lake, Inyo County, California, on July 7, 1928. The lake at this time was very low and on the western side, where the collecting was done, it was impossible to reach water more than half an inch in depth, overlying a slimy mud, which was swarming with Dipterous larvæ and pupæ, nothing else being found. There were great numbers of *Ephydra hians* Say, a species already recorded from this locality by Aldrich (1912). Pupal cases of a large *Tabanus* and many larvæ and pupæ of *Odontomyia* were found. The first named belonged to *T. punctifer* O. S., a common inhabitant of alkaline waters in the West (Webb and Wells), adults of which were caught in the near vicinity, and the latter are probably referable to *O. tumida* Banks, and *O. arcuata* Loew., both of which were obtained. No exact chemical and physical details of the environment of the latter two species appear to be on record. Brues (1928) records *T. punctifer* as occurring in waters with a specific gravity up to 1.014.

The composition of Owens Lake is already well known. According to Clarke (1924), the total salinity varies from 15,900 parts per million (specific gravity 1.015) to 213,700 parts per million (specific gravity 1.153). Considering the time of the year and the level of the lake, the insects obtained must have been living under conditions of salinity approaching those indicated by the higher figures.

The percentages of the chief constituents in the more saline samples are given below. The data have been calculated in parts per million, and are given in the second column so that the figures are comparable with those given in the other tables:

	Percentage of Total Salinity	p. p. m.
Cl	24.82	53,425
CO_3	24.55	52,463
SO_4	9.93	21,220
Na	38.09	81,398
K	1.62	3,461
Specific Gravity	1.153	

Mono Lake.—Owing to its greater depth and large size, Mono Lake is correspondingly more constant in composition. The following data are recalculated from Clarke:

Salinity	51,170	p. p. m.
Specific gravity	1.045	
Cl	11,943	p. p. m.
CO_3	11,984	
SO_4	6,580	
Na	19,408	
K	946	

The only aquatic insect definitely known from Mono Lake appears to be *Ephydra hians* (Aldrich, 1913, and many other observers), and this was the only one found by the writer on a very brief visit in October 1928. Aldrich records *Tabanus opacus* Coq., and *T. phænops* O. S., but it appears uncertain whether these were breeding actually in the lake or in streams running into it. *Ephydra subopaca* Loew., is also mentioned as occurring in seepage near the lake. Many other Diptera were recorded by Aldrich in the vicinity, but the breeding habits were not known.

Salton Sea.—This body of water is of particular interest in view of the great changes in salinity which must have taken place since its formation forty years ago. From 1891 till 1905 the lake was small and the salt content presumably high, although no data for that period appear to be available. From 1905-1907 fresh water from the Colorado River flowed in, with the result that the lake more than doubled its size. In 1911 the salinity was found to vary from 7164-7348 parts per million (MacDougal, 1914). After 1907 the inflow was checked, with the result that the salinity again began to increase and in 1913 had reached a salinity of 10,026 parts per million.

Hubbard in 1897 recorded four species of Coleoptera at a point near Salton where some springs, said to contain "1 to 6 per cent of saline matter," discharged into the sea. An undescribed species of *Creniphilus (Paracymus)* was described as present in vast numbers, with *Philhydrus diffusus* Lec.; and *Octhebius rectus* Lec., and a new species of the same genus were found less commonly. Hubbard also records an *Ephydra* different from that found in Great Salt Lake." Aldrich (1912) quotes a record of *E. gracilis* from this locality, but the specimens in my possession are all *E. subopaca,* not *gracilis.* Hubbard, in addition, records several salt marsh Staphylinids and Carabids.

I was, unfortunately, not able to reach the exact spot mentioned by Hubbard, but two visits to localities on the west shore of the lake failed to yield anything except immature Corixidæ, which could not be identified. All the specimens that I have from this particular region are two Ephydrids collected by Dr. E. A. Andrews, March 3, 1929, and very kindly handed over to me. They are *Ephydra subopaca,* and a *Paralimna* sp., but the latter can hardly have been breeding in the lake and there is some doubt about the *Ephydra.*

In contrast to the lack of insects in the Salton Sea, the insect fauna of a small tule-surrounded pool at Dos Palmas, a short way from the eastern shore of the lake, is of interest. This pool is fed by a luke-warm spring, an analysis of which is given below. Here, on December 12, 1928, larvæ of a species of Procladius were present in abundance, and larvæ of *Odontomyia* sp. were also found. Five species of Coleoptera were taken as follows:

Dytiscidæ. *Laccophilus mexicanus* Aubé; *Laccophilus terminalis* Sharp; *Rhantus binotatus* Harris.

Hydrophilidæ. *Tropisternus dorsalis* Brullé.

A few hundred yards away was a pool of fresh water containing abundant plant growth and mosquito larvæ, probably referable to *Anopheles pseudopunctipennis* Theob., and *Theoboldia inornata* Will., larvæ of *Odontomyia* sp. were also found. Here also occurred the Desert Minnow, *Cyprinodon macularcus.*

Analysis of springs at Dos Palmas:

	Dos Palmas	Canyon Springs
Cl	470	124
CO_3	0	0
HCO_3	115	155
SO_4	120	736
Ca	46	120
Mg	45	65
Na	270	230
Total Solids	1,020	1,388

A stagnant pool at Canyon Springs, about eight to ten miles away, contained nothing but mosquito larvæ, almost certainly those of *T. inornata,* a species already known from saline waters (Brues, 1928).

Discussion

Little need be said as to the composition of the waters, the tables will explain themselves. For the sake of comparison it may be said that the average specific gravity of sea water is 1.027, that of pure water, of course, being 1.000. It will thus be seen that many of the samples are much saltier than the sea, the most concentrated being that from Owens Lake, with a specific gravity 1.153. The waters are for the most part markedly alkaline, owing chiefly to the presence of large quantities of dissolved alkaline carbonates, and in some cases borax. It is, however, fairly well established that differences in p.H. of the medium have very little direct effect on aquatic insects, although, of course, the indirect effect by influencing the fauna and flora as a whole, may be very great. The high proportion of sulphates should also be noted.

In considering these waters as biological environments the most important point to know is, of course, the osmotic pressure. This cannot be measured in the field and, in the case of highly concentrated solutions, can only be estimated with some difficulty in the laboratory. In the case of sea water and brines produced by the evaporation of sea water, Fox (1926) has shown that no serious error is involved if it is assumed that the salts are completely ionized. Then the osmotic pressures can be taken as identical with those of solutions of pure NaCl of the same specific gravity, and for which the freezing point depressions are accurately known. This procedure is, of course, much less reliable in the case of waters such as are discussed in this paper, the salts of which are certainly not completely ionized, and figures obtained in this way will consequently tend to be too high; nevertheless, one or two examples, while only approximate, will serve to give some idea of the order of magnitude of this factor. Thus the osmotic pressure of Mono Lake would be about 50 atmospheres, that of the most concentrated of the Death Valley pools 28 atmospheres, whilst Owens Lake might reach as high as 175. The fact that the figures for Death Valley waters are so much lower than those for Owens Lake is probably due merely to the difference in the season at which the observations were made.

The observations here recorded supply further illustrations of the fact, already noted in many parts of the world (*e. g.*, Thorpe, 1927), that the Diptera are not only able to support life in media of an osmotic pressure that is rapidly fatal to most other insects, but that they have also a greater power of adaptation to changes in concentration than have other orders. As will be seen from these notes the waters of greatest salinity are occupied mainly by Dipterous larvæ, Coleopterous and Trichopterous larvæ occurring only at respectively lower concentrations.

Of the Ephydrids, *gracilis* and *hians* are well known as forms confined to saline waters. About *E. subopaca* there is some doubt. Aldrich says that in the West it is characteristic of the less dense waters (specific gravity 1.000 to 1.019), while Ping (1921), working in the East, states that it cannot go through its early stages in fresh water. The record from Salton appears to extend its known range in California by some five hundred miles to the south.[1]

Although unidentified Stratiomyidæ have frequently been recorded from saline and alkaline waters (Brues, 1928), the records from Owens Lake indicate a considerably higher salinity range than usual.

No exact data as to the habitat of any of the Coleoptera met with, excepting *T. dorsalis,* appear to have been recorded previously. *T. dorsalis* is recorded by Brues (1928) at specific gravity 1.0008 to 1.0015. With the possible exception of *H. panaminti,* the records suggest that all of these insects are also capable of developing in fresh water. The record of this species from Dos Palmas extends its known range south by two hundred miles. Dr. Fall tells me it was previously known only from the Death Valley region. It is seen to have a wide salinity range (specific gravity 1.001 to 1.024).

Finally I wish to express my indebtedness to Dr. H. C. Fall and Dr. O. A. Johannsen for determinations of the Coleoptera and Diptera respectively, and to the chemical department of the University of California Citrus Experiment Station at Riverside, for undertaking water analysis; to Mr. E. C. Jaeger of the Biology Department, Riverside Junior College, I am

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1 Unless E. millbræ, Jones, a common coast species in southern California, eventually proves to be identical.

much indebted, for without the advantage of his experience of desert travel some of the trips would not have been attempted.

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